COST AS AN INDEPENDENT VARIABLE: *CONCEPTS AND RISKS*

Dr. Benjamin C. Rush

Cost as an Independent Variable (CAIV), implemented in early 1996, is a new initiative to reduce defense system costs. Here we'll look at the definitions, concepts, processes, and risks of CAIV, with examples from the eight flagship programs that are leading in its use.

In the past decade of tremendous changes in defense systems acquisition, the most significant factor is the dramatic drop in dollars available to buy new systems. This mandates new thinking on strategies and processes for acquisition. Part of this change in thinking is Cost as an Independent Variable (CAIV), a new initiative to reduce life-cycle costs of defense systems. CAIV was proposed in 1995 and implemented in March 1996 as a part of the new 5000 Series regulations on defense systems acquisition (DoD 5000.2R, 1996). Compliance with the principles of CAIV is required for all acquisition category (ACAT) I and IA programs and, at the discretion of the component acquisition executive (CAE), the principles may be applied to other programs. Implementation of CAIV is basically in two steps: first, when a mission needs statement (MNS) is approved (and the concept exploration phase begins), an approach is laid out to set cost objectives; and, second, upon program initiation (usually at Milestone I approval), the actual life-cycle cost objectives are established by the program office.

Two Department of Defense (DoD) working groups led the definition and implementation of CAIV. A Defense Manufacturing Council working group developed a CAIV working group report disseminated in December 1995 which describes a strategy for setting aggressive, realistic cost objectives for acquiring defense systems and managing the associated risks. In June 1996, the Flagship Programs Workshops began meeting under the leadership of Dr. Spiros Pallas of the Office of the Secretary of Defense (OSD). The participants include representatives of eight defense programs, as well as representatives of OSD, the Institute for Defense Analyses (IDA) and the Defense Systems Management College (DSMC). Table 1 lists the eight flagship programs as well as their current program phase and

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a short description of the weapon system. Flagship programs are sharing problems and solutions in implementing CAIV policy.

DEFINITION

CAIV is a new DoD strategy that makes total life-cycle cost as projected within the new acquisition environment a key driver of system requirements, performance characteristics, and schedules. This is a 180-degree conceptual change in thinking from the days of requirement-, performance-, and sometimes schedule-driven costs. While the life-cycle cost–performance–requirements tradeoff process is the heart of CAIV, a broader definition is necessary to recognize the environment in which these trades take place. Programs are being aggressively managed to meet program objectives concomitantly with the implementation of reform initiatives such as: use of commercial specifications and practices; use of integrated product and process development teams; and contractor enterprise reengineering. Acquisition reform initiatives have the potential to significantly reduce cost and change the baseline against which cost–performance–requirements trades are benchmarked. The Defense Acquisition Deskbook provides a description of CAIV within this broader context: "CAIV is a strategy that entails setting aggressive yet realistic cost objectives when defining operational requirements, acquiring defense systems, and managing achievement of these objectives. Cost objectives must balance mission needs with projected out-year resources, taking into account existing technology, maturation of new technologies, and anticipated process improvements in both DoD and industry" (DoD, 1996). In some ways CAIV suffers from the combination of too many initiatives to be easily explained. Philosophically CAIV is the combination of all the best practices affecting cost.

CONCEPTS

The implementation of CAIV requires new thinking about program management. If cost is truly the key driver of performance and schedule, no single cost reduction strategy is likely to be sufficient. All cost reduction initiatives must be considered. In a presentation by the Institute for Defense Analyses at the Flagship Workshop in July 1996 (Bell, 1996), a hierarchy of CAIV cost levers was proposed. All of these levers are important in CAIV implementation. They are listed in rough order of potential benefit for most programs:

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PROGRAM	PROGRAM DESCRIPTION	PROGRAM STATUS
EELV	A more cost-effective space launch vehicle for medium and heavy lift requirements	Pre-EMD start Dec. 1996
AIM-9X	Next generation Sidewinder air-to-air missile	EMD start Jan. 1997
TACMS-BAT P3I	Upgrade of tactical ground-to-ground missile - new seeker	Currently in PDRR EMD start in 1998
MIDS	Third generation secure, jam-resistant, communications system for NATO family	EMD contract awarded in Mar 1994 Restructured Jun. 1994 CDR in-process
JASSM	Long-range air-to-surface standoff missile	Entered 2-year competitive PDRR
CRUSADER	155MM self-propelled Howitzer and armored resupply vehicle	Completion of PDRR in FY 2000 Single contractor team
JSF	Advanced Strike Fighter Aircraft	Pre-PDRR
SBIRS	Space-based infrared surveillance system for missile defense	Entered EMD for GEO in FY 1996 PDRR for LEO with MS II in FY 1999

Table 1. CAIV Flagship Programs

1. Requirements–cost–performance trades. This is the essence of CAIV and is discussed in detail in following sections.

2. Acquisition strategy. Competition is the greatest lever that the government has in the early stages of a program to ensure that CAIV objectives are met. Because of this, competition should be maintained as long as economically practical.

3. Concurrent engineering/integrated product and process development (IPPD). To meet an aggressive cost target, team members must cooperate to ensure that all functional planning be integrated and that difficulties are discovered and resolved early on.

4. Contractor enterprise reengineering. The lean enterprise philosophy encourages industry to concentrate on core capabilities and to develop

long-term relationships with key suppliers for non-core activities. It also requires that core activities be conducted with maximum efficiency.

5. Commercial specifications, practices, and components. Acquisition reform has enabled use of commercial specifications and practices in many areas. The use of commercial components, where technically feasible, is an important cost reduction tool for many programs.

DoD expects cost savings from these cost levers to enable 50 percent and greater reductions in cost from the old way of doing business. The Joint Direct Attack Munitions Program is a frequently cited example of a program that is achieving this magnitude of reduction from the broad impact of the new way of doing business.

The preceding consistently addresses the tradeoff process as cost–performance and requirements. This emphasizes the role of the user and the importance of the transition from the requirements process to contracting for system performance goals. The process considers the changing nature of requirements as system development progresses. To enhance the effectiveness of CAIV, programs minimize the number of system performance parameters stated in the Operational Requirements Document (ORD) at Milestone (MS) I. This allows performance objectives to be developed that are achievable and affordable based on actual development and additional analysis during Program Definition and Risk Reduction (PDRR). If the number of key performance parameters are kept to a minimum while continuing to meet the user's real needs, greater leeway is provided for future tradeoffs. The system performance parameters called out in the ORD are designated key performance parameters and are not tradable below a threshold value. Thus for key performance parameters the only trade space is between threshold and objective values. Both values are stated in the ORD and in the Acquisition Program Baseline (APB), and using the CAIV strategy are refined until MS II.

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For technical performance parameters, the CAIV targets should be the same as those in the APB. For CAIV cost threshold and objective values, there are potential problems with having them equivalent to the APB values. The program budget cannot exceed the APB cost threshold and the cost threshold is specified as 10 percent above the objective value (5000.2R, Part 3.2.1 and 3.2.2.2). This may provide little cost room to solve technical performance parameter breaches.

To some extent, previous attempts at cost–performance trades fell victim to inflexible requirements from the user or overspecified requirements by the acquirer. Performance goals have frequently been driven by available technology where the contractor and program management office (PMO) strive for "the last ounce of performance." The threshold and objective values for key performance parameters are initially developed as the user translates the broadly stated

mission need from the mission area analysis into a system description for the ORD. An analysis of alternative system concepts should focus on determining the appropriate technical performance trades prior to the initial ORD and APB at Milestone I. The key performance parameters are stated in the initial ORD and APB and updated at each milestone. For effective contracting, performance must be stated as overall system performance goals rather than as detailed specific performance parameters. Changing these goals during system development because of changing mission requirements from the user will greatly hinder the CAIV process. Further, the user and acquirer must be willing to accept lesser performance for less cost within the trade space. Changing the culture regarding lesser but acceptable performance is critical to successful implementation of CAIV. Thus, the user must be an integral player throughout the process as the cost–performance–requirements tradeoffs are made in each phase of the life cycle.

Clearly the tradeoff process is more effective if it can be accomplished earlier in the design process. A large percentage of the cost is determined by a small percentage of the design decisions. These critical cost-driving design decisions normally are made very early in the concept selection and design process. Because of this, expect greater success in implementing CAIV for programs in concept exploration or program definition and risk reduction phases. There are significant problems estimating production and operations and support (O&S) costs early in development but these estimates can be updated and improved over the product's life cycle. Improved estimates will have the greatest program impact if competition continues.

How is this different from design-to-cost (DTC)? This question is frequently asked in discussions on CAIV. CAIV embodies more than the tradeoff process that is DTC and there are key conceptual differences. Under CAIV, the user is an active participant in the tradeoff process throughout the life cycle. This is not normally the case with DTC. Another key difference is CAIV's more flexible requirement based on threshold mission effectiveness. Earlier planning in the life cycle by the user and acquirer with an iterative refining of the objectives is another difference. In the past, DTC has been predominantly a contractor's process, executed during the system design. In the simplest terms, consider DTC as one of the tools for the implementation of the CAIV concept.

Processes

The DoD initiative on IPPD and integrated product teams (IPTs) is central to the implementation of CAIV. Within both contractor and government organizations, it is expected that this initiative will have been implemented. Under the direction of the government program manager (PM), a cost–performance IPT (CPIPT) will establish the program cost objectives and facilitate the cost–performance–requirements tradeoff process. Team membership includes the user from the outset, and contractor representation as it is determined appropriate (as per 5000.2R, Part 1, Section 1.6). Other members vary depending on the phase of the life cycle but could include the service cost center and

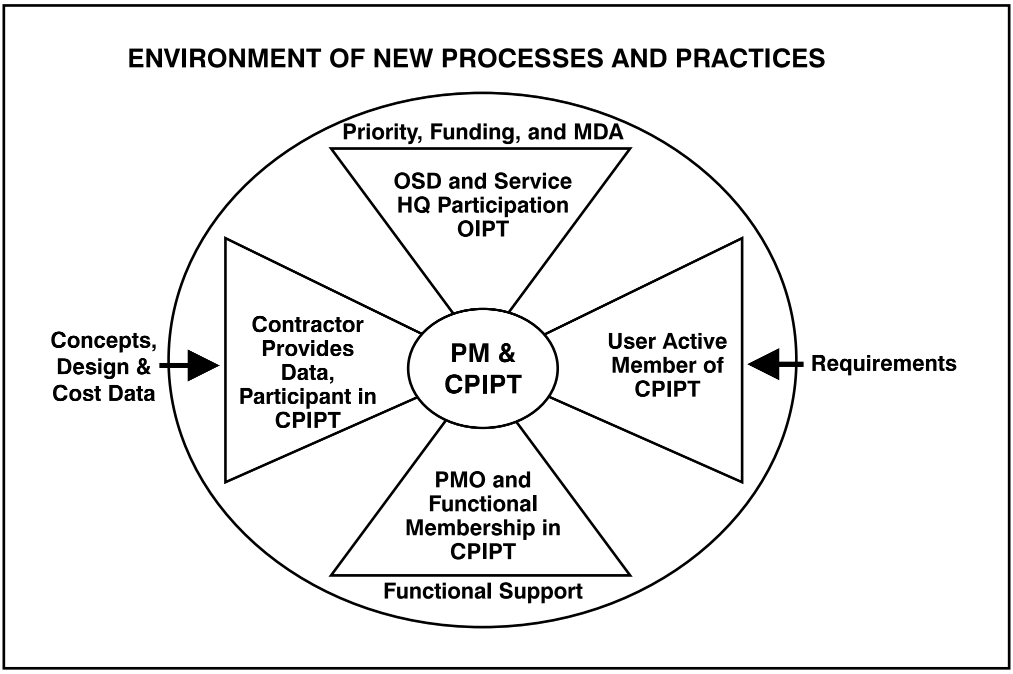

Figure 1. Participants in the CAIV Process

the OSD Cost Analysis Improvement Group (CAIG) as does the Joint Air-to-Surface Standoff Missle (JASSM) program. A detailed discussion of the membership and roles of the CPIPT is provided in the "Life Cycle Cost-Performance Concept Paper" (DoD, 1995).

The CAIV process is an iterative one focused on the PM and CPIPT (Figure 1). The PM and CPIPT work with the Overarching-IPT representing the program evaluation officer, service headquarters, and OSD in determining funding, receiving programmatic direction, and providing program status. The PM and CPIPT must have a strong working relationship with the user community in establishing cost-effective requirements and determining priority. The PM and CPIPT have a number of supporting acquisition organizations, from functional support within the component command to service cost centers, which provide cost estimates and analysis. Design and cost analysis by the contractors provide the CPIPT with the information necessary to analyze cost–performance tradeoffs. This circle of relationships around the PM and CPIPT enable a sequence of activities necessary to accomplish CAIV. These include the development of aggressive cost goals, implementation of incentives to encourage the accomplishment of these goals, and measurement of specific CAIV performance through tracking of metrics.

SETTING AGGRESSIVE COST TARGETS

Developing aggressive cost goals requires the CPIPT to consider a number of elements, including available resources, costs of comparable systems and components, mission effectiveness studies, tech-

nology base trends, and the use of such initiatives as lean manufacturing and commercial business practices. The CPIPT must work to develop initial aggressive cost goals using these elements and the following framework.

1. Using affordability as the key criterion, the service headquarters divides a fixed budget among competing programs. Here the cost goals are used in developing budget required for that program and compared with the available dollars in the Program Objective Memorandum (POM) years based on the priority level established by the service, Joint Requirements Oversight Council (JROC), and others. This fixed budget based on the priority of the program is the reality of what is available for structuring the program. The current budget may be less constraining in the out years, but still drive the program acquisition strategy.

2. Using mission effectiveness as the key criteria, the user and service headquarters must determine "the most bang for the buck" of the proposed system. Here analytical studies begin with mission area analysis and analysis of alternatives and result in a set of requirements in a mission need statement and the ORD. This analysis would look at the proposed program in terms of mission effectiveness versus performance requirements and performance requirements versus cost. There are different DoD organizational elements involved in this analysis, depending on the service: Center for Naval Analyses (Navy), Training and Doctrine Command (TRADOC) (Army), combat command (Air Force), and Program Analysis and Evaluation (PA&E) (OSD). These studies provide the necessary tie between mission requirements, performance parameters, and the cost effectiveness required of the system.

3. The PMO would normally have access to independent research and contract studies by contractors, which provide concepts and cost estimates for achieving the required system performance requirements. These concepts and associated costs may vary widely from one study to the next but provide the critical contractor perspective on range of alternatives and provide key data to the above-mentioned analysis of alternatives and funding exercises.

The PM, through the CPIPT, must find a set of initial cost goals that provide an affordable budget and still enable the system to meet at least the threshold requirements of the user. If the cost goals include consideration of the most likely cost of the performance and schedule requirements, there can exist a legitimate trade space for cost–performance tradeoffs and the cost targets will be realistic. If initial realistic cost goals cannot be developed through this trade program within the budget affordability, the program is not viable. The initial cost goals will be refined at each stage of development to ensure a balance between the realistic and the aggressive. They will be referred to as cost

goals by Milestone I, as cost targets by Milestone II, and firm cost targets by Milestone III.

The key focus of CAIV is on the total life-cycle cost (LCC) of a program with LCC in four separate cost objectives: research, development, test, and evaluation (RDT&E); production; operations and support; and disposal. Here we give primary attention to the production cost objective and the operations and support cost objective reflecting the emphasis of the flagship programs.

The production cost objective is defined in several ways. The basic term associated with production costs of individual items of a program is known as "average procurement unit costs" (APUC). The APUC is calculated by dividing the total procurement cost by the total procurement quantity of the program. Also of interest to a PM is the average unit cost of those items contracted for in each production lot. The average unit production cost of a production lot will normally vary from one production lot to the next based on learning curve theory and other factors. Further, the production lot average unit values will be different from the APUC, which is based on the total program quantity. Additional confusion can occur when one compares production costs of different programs, because of different definitions. Examples from the JASSM and AIM-9X flagship programs are the inclusion in production costs of "bumper to bumper" warranty costs (although for differing periods). Other programs have no warranty costs in their average unit costs.

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The second area of operations and support costs is even more difficult to predict. Contractually, operations and support costs may best be handled (as several of the flagship programs have done) by setting aggressive goals for key performance parameters that drive O&S costs, such as mean time between failure (MTBF) and mean time to repair (MTTR).

Implementation of Incentives

The implementation of incentives is a critical part of ensuring the necessary changes. These incentives can be either positive (achieving targets) or negative (failure to meet targets). If the contractor is not meeting the program cost targets, an acquisition strategy could be structured to restart competition. An acquisition strategy guide provides the optimum level of competition by phase is one of the most effective ways to ensure cost is minimized. Flagship program examples are the JASSM and Evolved Expendable Launch Vehicle (EELV) programs, which use rolling down-selects (selecting fewer contractors for each succeeding phase) with the final development contract competition including low-rate initial production and the incentive of continuation in a sole-source mode as long as the final cost targets structured during the final competition are not breached.

In many programs, the quantity or other factors prevent the ability to have competition in production. In these situations, the use of award or incentive profit can play a major role. The Crusader program is an example of a program with a sole-source

contractor in development through procurement, where an award fee is being used to motivate contractor performance. This is in an environment of minimal milspecs, mil-stds, and contract data requirements lists. The Space-Based Infrared Systems (SBIRS) program uses an incentive fee to share the cost savings between the government and the contractor. An important motivator for all programs is the shared decision role through contractor participation on the CPIPT.

Another element is providing appropriate incentives to the government employees who make major contributions to the success of the program. This has been tried with mixed success. One of the major difficulties is that monetary awards are not allowed for military members of the government team, but a change in the law is under study.

Measuring Performance Through Tracking of Metrics

There is a need for validated cost models to track life-cycle cost during program execution. The government should have access to contractors' models and methodology. This does not mean that the government and contractor have the same models, but they work together to share and validate. The contractor's design-to-cost system must provide a flow-down of the APUC to the engineering design level with status reporting, corrective actions, and trend analysis. The reporting process is incorporated into the contract statement of work. The Crusader program showed that the models used for trades were inadequate for cost tracking. The AIM-9X program demonstrated that it was extremely valuable to establish early a government–contractor APUC working group. An APUC baseline can later be altered to account for government-directed design changes, quantity changes, and economic price adjustments. Any change in the baseline must be directly traceable so that the cause and magnitude are documented.

The operations and support costs tracking process has been handled by the flagship programs in one of two ways. Where the contractor has provided a warranty as part of the APUC, the government need only be concerned with the cost models at the time of warranty negotiation. When there is no warranty, the government interest shifts to the impact of the technical cost drivers. The system O&S costs are best controlled through test and analysis of the technical parameters driving O&S costs such MTBF and MTTR. Technical performance measurement should be used to track all critical performance parameters including those driving O&S costs.

Risk Management in CAIV

The areas of risk listed below must be addressed as a part of the CAIV process. Some of these risks are in conflict with others; they must be continually balanced. The process is an iterative one and the risks come into play multiple times during the life of the program. Among the key areas that CAIV must consider are:

1. Risks that the current budget and priority decisions for a system are sufficiently accurate and remain stable over the program life cycle to provide realistic system affordability.

The program budget must be realistic and stable for a successful program. This is a major problem in managing most acquisition programs; it will be even more critical under CAIV, where cost explicitly drives performance and schedule.

2. Risks that the threshold performance requirements will provide the necessary mission effectiveness and will be stable during system development and production, and risks that the difference between threshold and objective requirements will provide sufficient trade space to allow tradeoffs between cost, schedule, and performance.

   The balance between ensuring that the system will meet the user's true requirements and the necessity of the threshold requirement being sufficiently low that real trade space exists between the threshold and objective is critical to the tradeoff process.

3. Risks that the shape of the function between performance, requirements, mission effectiveness, and cost can be determined and utilized in tradeoff analysis.

   The determination of this function and the desire to find the "knee of the curve" will require not only good cost data but extensive modeling of mission effectiveness. An excellent example is the work of the Joint Strike Fighter program in modeling these relationships.

4. Risks that the historical database for parametric estimates used in cost effectiveness assessment is sufficiently applicable to the system being estimated to provide an accurate most likely value and range (or probability distribution function) for the costs of the system.

   The database for parametric estimates always seems populated with programs that are sufficiently different in technology, design, or mission from your program so as to call into question the validity of the estimate. To achieve good tradeoffs, one must have good cost models with valid data reflecting the current acquisition reform initiatives.

5. Risks that the interrelationships of the system performance requirements are sufficiently understood to select the most cost-effective system performance objectives, and risks that the performance requirements are accurately translated to system performance contractual goals, which the contractor has sufficient incentive to achieve.

   The system performance goals are seldom independent. Understanding these interrelationships is critical to contracting with and providing incentive to the contractor.

6. Risks that the contractor DTC analyses accurately direct the system performance objectives to specific design and process decisions, and risks that the contractor detail

engineering (bottoms-up) cost data at the design level is sufficiently accurate to make the most cost effective design trades.

Does the contractor have a good DTC process? Without one, achievement of aggressive cost targets is unlikely.

7. Risks that technology developments will enable the achievement of specific design and process goals.

   If the performance requirements are too ambitious and can't be achieved, the cost and schedule of technology development will become the drivers.

   The central feature of CAIV is the tradeoff process; determining affordable performance and scheduling based on cost goals is accomplished by a set of decisions that balance the above risks.

SUMMARY

The flagship programs will demonstrate the ability of the CAIV concept to achieve significant savings. Results will not be available for some time. In the meantime, all major defense acquisition programs in the first two phases of the life cycle are charged with implementing this concept and were required to submit a paper on CAIV implementation by July 1, 1996. These programs continue to report progress on this concept annually to their Milestone Decision Authority. We hope this and other articles on the implementation progress of CAIV will increase understanding of the concepts and, by so doing, further its ability to succeed as a key strategy in the management of all defense system acquisitions.

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